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1 **Test-meal palatability is associated with overconsumption but better represents preceding**
2 **changes in appetite in non-obese males.**

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18 **Running title:** Comparative sensitivity of ad libitum meals

19 **Key words:** Energy intake; Preload; Compensation; Sensitivity

20 ABSTRACT

21 Single course ad libitum meals are recommended for the assessment of energy intake within appetite
22 research. This represents the first investigation of the comparative sensitivity of two single course ad
23 libitum meals designed to differ in palatability. Two experiments were completed using a preload
24 study design. All protocols were identical except for the energy content of the preloads (Experiment
25 one: 579kJ and 1776kJ; Experiment two: 828kJ and 4188kJ). During each experiment, 10 healthy
26 men completed four experimental trials constituting a low or high energy preload beverage, a 60 min
27 intermeal interval, and consumption of a pasta-based or porridge-based ad libitum meal. Appetite
28 ratings were measured throughout each trial and palatability was assessed after food consumption.
29 Preload manipulation did not influence appetite ($P=0.791$) or energy intake ($P=0.561$) in experiment
30 one. Palatability and energy intake were higher for the pasta meal than the porridge meal in both
31 experiments (palatability $P\leq 0.002$; energy intake $P\leq 0.001$). In experiment two, consumption of the
32 high energy preload decreased appetite ($P=0.051$) and energy intake ($P=0.002$). Energy compensation
33 was not significantly different between pasta and porridge meals ($P=0.172$) but was more strongly
34 correlated with preceding changes in appetite at the pasta meal ($r=-0.758$; $P=0.011$) than the porridge
35 meal ($r=-0.498$; $P=0.143$). The provision of a highly palatable pasta-based meal produced energy
36 intakes that were more representative of preceding appetite ratings but the moderately palatable
37 porridge-based meal produced more ecologically valid energy intakes. Ad libitum meal selection and
38 design may require a compromise between sensitivity and ecological validity.

39 INTRODUCTION

40 The increase in obesity prevalence during recent decades has stimulated an abundance of research
41 into the regulation of appetite and energy balance in humans. This research frequently includes the
42 objective measurement of energy intake during ad libitum meals in response to nutritional^(1,2),
43 pharmaceutical^(3,4) and exercise interventions^(5,6). Such monitoring of energy intakes under laboratory
44 conditions is recommended due to the dubious accuracy of self-reported measures^(7,8) and a range of
45 ad libitum meals have demonstrated high levels of repeatability in quantifying energy intakes^(9–13).
46 However, despite the prevalent use of ad libitum feeding, there has been little investigation into the
47 sensitivity of these meals to reflect changes in appetite and only one study to date has compared the
48 sensitivity of commonly used ad libitum meals. In this regard, Wiessing and colleagues⁽¹⁴⁾ recently
49 demonstrated a similar energy compensation of ~28% in response to a high versus low energy preload
50 when assessing energy intake via an ad libitum buffet meal and single course pasta-based meal.
51 However, both meals promoted overconsumption with mean intakes greater than 4500 kJ at each
52 meal after the low energy preload.

53 Single course meals are recommended for the assessment of ad libitum energy intake due to concerns
54 that buffet meals delay satiation and promote overconsumption, thereby not reflecting the habitual
55 intakes of participants⁽⁷⁾. However, overconsumption during single course pasta-based meals is
56 commonly reported in the literature, with mean intakes ranging from ~3200 to ~6400 kJ in a range of
57 participant populations^(1,14–20). Such large intakes are likely to be due to the high palatability of pasta-
58 based ad libitum meals^(14,21). It has previously been demonstrated that increasing the palatability of
59 ad libitum meals can enhance appetite during feeding, induce overconsumption and reduce the
60 sensitivity of the meal to detect prior changes in appetite⁽²²⁾. Subsequently it seems plausible that
61 overconsumption during pasta-based meals may contribute to the dissociations observed between
62 appetite ratings and food intake responses in previous studies^(1,15,18).

63 Recent studies by Corney et al.^(23,24) have used an ad libitum porridge meal to assess energy intake
64 and reported mean intakes of ~2500 kJ after an overnight fast in healthy young men. These intakes
65 are substantially lower than those reported from pasta meals within similar populations^(15–18); are more
66 representative of expected habitual intakes (increasing external validity); and may produce greater
67 sensitivity to prior changes in appetite by reducing overconsumption (enhancing precision). However,
68 due to large individual differences in energy intake during ad libitum feeding combined with the
69 subjectivity of appetite perceptions, direct comparisons within subjects are essential for appropriate
70 assessment of appetite and energy intake responses to an intervention⁽⁷⁾.

71 Thus, the purpose of this study was to compare the sensitivity of a pasta-based versus a porridge-
72 based ad libitum meal for the assessment of energy intake. This represents the first comparison of
73 two commonly used single course ad libitum meals and provides guidance on the selection of ad
74 libitum meals for future research studies. We hypothesised that ad libitum energy intake at the
75 porridge-based meal would be more ecologically valid and more representative of preceding appetite
76 ratings than energy intake at the pasta-based meal.

77 **METHODS**

78 **Study design**

79 This investigation contained two experiments which were conducted according to the guidelines laid
80 down in the Declaration of Helsinki. Both experiments involved a preload study design to investigate
81 the influence of ad libitum meal composition on the compensatory energy intake response to different
82 energy preloads. The experimental protocols were identical, except for the energy content of the
83 preloads. Experiment one was conducted at the University of Bath and compared the effects of a 579
84 kJ and 1776 kJ preload. Experiment two was conducted at Leeds Beckett University and compared
85 the effects of an 828 kJ and 4188 kJ preload. The use of different preloads in each experiment enabled
86 comparisons to be made regarding the effects of moderate and large differences in preload energy
87 content. Each experiment was approved by the Institutional Ethics Advisory Committee for the
88 university at which the experimental testing was performed and written informed consent was
89 obtained from all participants.

90 **Participants and standardisation**

91 Study participants were non-smokers, not taking medication, weight stable for at least six months
92 before participation and were not dieting. Participants had no known history of
93 cardiovascular/metabolic disease, were classified as unrestrained eaters⁽²⁵⁾ and were recreationally
94 active.

95 In both experiments, participants completed a food diary detailing all foods and drinks consumed in
96 the 24 h before their first experimental trial and replicated this before each subsequent trial. Alcohol,
97 caffeine and strenuous physical activity were not permitted during this period. All trials commenced
98 between 8am and 9am after an overnight fast of at least 10 h and participants exerted themselves
99 minimally when travelling to the laboratory, using motorised transport when possible. Verbal
100 confirmation of dietary and exercise standardisation was obtained at the beginning of each
101 experimental trial.

102 **Experimental protocol**

103 For each experiment, 10 healthy men performed four experimental trials separated by a minimum of
104 72 h in a randomised, semi-double blind (blinded to the preload composition but not the test meal)
105 crossover design. The four trials constituted a low energy or high energy preload, followed by an ad
106 libitum test meal that was either pasta-based or porridge-based. Anthropometric measurements,
107 screening for eating behaviours⁽²⁵⁾, habitual physical activity levels and verbal confirmation of the
108 acceptability of the foods to be provided during the study were obtained immediately before the first
109 experimental trial. Habitual consumption of pasta-based and porridge-based meals was assessed using
110 an eight-point scale ranging from “almost never” to “more than two meals per day”.

111 Upon arrival to the laboratory for each experimental trial, participants completed a baseline appetite
112 visual analogue scale before consuming a low or high energy preload beverage. Participants were
113 instructed to consume the beverage within five minutes and a 60 min intermeal interval commenced
114 upon the first mouthful of the beverage in accordance with Almiron-Roig et al.⁽²⁶⁾. Participants rested
115 within the laboratory (sitting reading or listening to music) throughout the intermeal interval and were
116 provided with an ad libitum pasta-based or porridge-based meal at 60 min.

117 **Preloads**

118 The preload beverages were matched for macronutrient composition and were designed to closely
119 align with the UK dietary guidelines for macronutrient proportions (58% carbohydrate, 26% fat, 16%
120 protein). The preloads consisted of water, single cream (Tesco, UK), maltodextrin (MyProtein, UK),
121 whey protein isolate (MyProtein, UK) and vanilla flavouring (MyProtein, UK). These beverages were
122 comparable to those used in previous research⁽¹⁹⁾. The energy content of the preload beverages was
123 579 kJ and 1776 kJ in experiment one and 828 kJ and 4188 kJ in experiment two. All preload
124 beverages weighed 550 g and were distributed evenly between two 568 mL glasses in order to
125 disguise any subtle differences in volume. All beverages were consumed by participants in isolation.
126 The preloads were prepared by a third party external to the study and both the researcher and
127 participant were asked to identify which beverage they thought had been consumed at the end of each
128 trial. All participants were fully unblinded upon completion of the experiment.

129 **Appetite and palatability assessment**

130 Appetite perceptions (hunger, satisfaction, fullness and prospective food consumption) were assessed
131 at baseline and every 15 min during both experiments using 100 mm visual analogue scales with
132 descriptors anchored at each end describing the extremes (e.g. “I am not hungry at all”/ “I have never
133 been more hungry”)⁽²⁷⁾. Participants rated their appetite perceptions by placing a mark across each
134 line on paper and participants were not able to refer to their previous ratings when completing the
135 appetite scales. The scales were analysed by measuring the horizontal distance from the left hand side

136 of the continuum to the point on the line indicated by the participant. Each visual analogue scale was
137 measured twice to ensure accuracy. A composite appetite score was calculated for each time-point as
138 the mean value of the four appetite perceptions after inverting the values for satisfaction and
139 fullness⁽²⁸⁾. Palatability ratings (visual appeal, smell, taste, aftertaste and pleasantness) were obtained
140 for the preloads and ad libitum meals immediately after consumption⁽²⁷⁾. A composite palatability
141 score was calculated as the mean value of the palatability subscales.

142 **Ad libitum meals**

143 The ad libitum meals were matched for macronutrient content and were designed to closely align with
144 the UK dietary guidelines for macronutrient proportions (52% carbohydrate, 34% fat and 14%
145 protein). The meals were also matched for energy density (8.45 kJ/g). The pasta-based meal consisted
146 of penne pasta (Tesco, UK), cheddar cheese (Tesco, UK), tomato sauce (Tesco, UK) and olive oil
147 (Tesco, UK) in accordance with previous research^(15,16). Pasta was cooked for 15 min in unsalted
148 water at 700 W before being mixed with the remaining ingredients and reheated for 2 min at 700 W.
149 The porridge-based meal consisted of rolled oats (Tesco, UK), whole milk (Tesco, UK), double cream
150 (Tesco, UK), maltodextrin (MyProtein, UK) and whey protein isolate (MyProtein, UK). The oats
151 were cooked in the microwave with milk and double cream for 2 min at 700 W before being mixed
152 with the remaining ingredients.

153 Participants consumed the ad libitum meals in isolation in order to prevent any social influence
154 affecting food intake. Participants were provided with a bowl of the respective meal and this was
155 replaced by an investigator before the participant had emptied it and with minimal interaction. Each
156 portion of the porridge-based meal weighed 300 g and each portion of the pasta-based meal weighed
157 430 g before consumption. Three bowls of the respective meal were prepared for each trial in
158 accordance with previous research⁽¹⁵⁾, which met the requirements of all participants during the trials.
159 No time limit was set for eating and participants were instructed to eat until ‘comfortably full’.
160 Subsequently, participants determined the point of meal termination and were asked to leave the
161 feeding area and inform the researcher once they felt ‘comfortably full’. Food intake was determined
162 as the weighted difference in food before and after eating. Water was available ad libitum during the
163 participants’ first trial and standardised for each subsequent trial. Energy compensation was
164 calculated using the following equation:

$$\text{Energy compensation (\%)} = [(EI_{\text{Low energy preload}} - EI_{\text{High energy preload}}) / \text{Energy difference between preloads}] \times 100].$$

167 **Statistical analysis**

168 Data for each experiment was analysed separately using IBM SPSS statistics version 19 for Windows.
169 Total area under the curve (AUC) values were calculated for appetite perceptions using the
170 trapezoidal method. Repeated measures, two-way ANOVA (preload x meal) was used to assess
171 differences in energy intake, composite palatability scores and AUC values for composite appetite
172 scores between the trials. Pearson product-moment correlation coefficient was used to examine the
173 relationship between energy intake and preceding appetite ratings. This included correlations between
174 the change in appetite scores and percentage energy compensation in response to the high energy
175 preload compared with the low energy preload in order to determine the utility of the test meals to
176 reflect changes in appetite. Wilcoxon signed-rank was used to assess differences between the habitual
177 consumption of pasta-based and porridge-based meals. Statistical significance for this study was
178 accepted as $P \leq 0.05$. Participant characteristics are presented as mean (SD). All other results are
179 presented as mean (95% CI). A sample size of 10 participants was determined to be sufficient to
180 detect an energy compensation of 40% in experiment one and 15% in experiment two, based on
181 previous data from Corney et al.⁽²³⁾. This calculation was performed using G*power with an alpha
182 value of 5 % and a power of 80 %⁽²⁹⁾. Individual compensatory responses are plotted within the figures
183 to allow for further examination of the findings and the results of each experiment are presented
184 separately to ensure clarity.

185 **RESULTS**

186 **Experiment One**

187 **Participant characteristics**

188 Participant characteristics were as follows: age 22 (1) years; height 1.80 (0.06) m; body mass 81.1
189 (7.9) kg; body mass index 24.8 (1.6) kg.m⁻². There was no significant difference in the habitual
190 consumption of pasta-based and porridge-based meals (P = 0.917) with the same median intake of
191 one meal per week. Habitual consumption of pasta-based meals ranged from “almost never
192 consumed” to “five to six meals per week”, whereas porridge-based meals ranged from “almost never
193 consumed” to “one meal per day”.

194 **Energy intake**

195 Two-way ANOVA revealed higher ad libitum energy intake during the pasta meal compared with the
196 porridge meal (P < 0.0005) but no difference between the 579 kJ and 1776 kJ preloads (P = 0.561)
197 (Figure 1a). There was no significant difference in energy compensation between test meals (P =
198 0.922) (Figure 1b).

199 **Appetite and palatability ratings**

200 Two-way ANOVA demonstrated similar results for each appetite perception with no significant
201 differences between preloads or test meals for hunger (preload: P = 0.694; meal: P = 0.928),
202 satisfaction (preload: P = 0.420; meal: P = 0.239), fullness (preload: P = 0.338; meal: P = 0.233) or
203 PFC (preload: P = 0.241; meal: P = 0.862). Subsequently, composite appetite scores are presented for
204 clarity.

205 Composite appetite scores did not differ between trials at baseline (P = 0.421). Two-way ANOVA
206 revealed no significant difference in composite appetite AUC between the 579 kJ and 1776 kJ preload
207 trials (P = 0.791). Similarly there was no difference in appetite scores between the pasta and porridge
208 trials (P = 0.523; LE Porridge 70 (10), LE Pasta 64 (9), HE Porridge 65 (14), HE Pasta 68 (14))
209 (Figure 2).

210 Two-way ANOVA demonstrated no significant differences in composite palatability scores for the
211 high energy preload compared with the low energy preload (P = 0.136). The palatability response to
212 preloads was not different during the pasta and porridge trials (P = 0.218). Composite palatability
213 scores for the test meals were significantly higher for the pasta meal compared with the porridge meal
214 (P = 0.001). The palatability response to the test meals was not different during the high and low
215 energy preload trials (P = 0.431) (Figure 3).

216 The preload beverage was correctly identified by participants in 21 of the 40 trials and by the
217 researcher in 5 of the 40 trials.

218 **Correlations**

219 Composite appetite AUC values were not significantly correlated with energy intake in any of the
220 four trials (all $r < 0.438$; $P > 0.205$). Energy compensation at the ad libitum meals was not significantly
221 correlated with the change in AUC or 60 min composite appetite scores between the 579 kJ and 1776
222 kJ preloads (Pasta AUC: $r = 0.077$, $P = 0.832$; Pasta 60 min: $r = -0.497$, $P = 0.143$; Porridge AUC: r
223 $= -0.452$, $P = 0.190$; Porridge 60 min: $r = -0.385$, $P = 0.272$) (Figure 2).

224 **Experiment Two**

225 **Participant characteristics**

226 Participant characteristics were as follows: age 21 (4) years; height 1.80 (0.05) m; body mass 77.2
227 (6.4) kg; body mass index 24.2 (2.3) $\text{kg}\cdot\text{m}^{-2}$. Habitual consumption of pasta-based meals was
228 significantly higher than porridge-based meals ($P = 0.014$) with median intakes of “two to four meals
229 per week” and “one meal per week”, respectively. Habitual consumption of pasta-based meals ranged
230 from “one meal per week” to “two to four meals per week”, whereas porridge-based meals ranged
231 from “almost never consumed” to “two to four meals per week”.

232 **Energy intake**

233 Two-way ANOVA demonstrated higher ad libitum energy intake after the 828 kJ preload compared
234 with the 4188 kJ preload ($P = 0.002$) and during the pasta meal compared with the porridge meal (P
235 $= 0.001$) (Figure 4a). However, there was no significant difference in energy compensation between
236 test meals ($P = 0.172$) (Figure 4b).

237 **Appetite and palatability ratings**

238 Two-way ANOVA demonstrated similar results for each appetite perception with higher hunger ($P =$
239 0.066), higher PFC ($P = 0.035$), lower fullness ($P = 0.062$) and lower satisfaction ($P = 0.077$) after
240 consumption of the 828 kJ preload compared with the 4188 kJ preload. There were no significant
241 differences for any of the appetite perceptions between the pasta and porridge trials (hunger: $P =$
242 0.531 ; satisfaction: $P = 0.813$; fullness: $P = 0.654$; PFC: $P = 0.327$). Subsequently, composite appetite
243 scores are presented for clarity.

244 Composite appetite scores did not differ between trials at baseline ($P = 0.642$). Two-way ANOVA
245 revealed higher composite appetite AUC after consumption of the 828 kJ preload compared with the
246 4188 kJ preload ($P = 0.051$). Appetite AUC responses to the preloads did not differ between pasta

247 and porridge trials ($P = 0.642$; LE Porridge 69 (9), LE Pasta 66 (13), HE Porridge 57 (18), HE Pasta
248 58 (20)) (Figure 5).

249 Two-factor ANOVA demonstrated higher composite palatability scores for the 4188 kJ preload
250 compared with the 828 kJ preload ($P = 0.001$). The palatability response to preloads was not different
251 during the pasta and porridge trials ($P = 0.877$). Composite palatability scores for the test meals were
252 significantly higher for the pasta meal compared with the porridge meal ($P = 0.002$). The palatability
253 response to the test meals was not different during the low and high energy preload trials ($P = 0.888$)
254 (Figure 6).

255 The preload beverage was correctly identified by the participant in 26 of the 40 trials and by the
256 researcher in 15 of the 40 trials.

257 **Correlations**

258 Composite appetite AUC values were more strongly correlated with energy intake during the pasta
259 trials than the porridge trials (LE Porridge: $r = 0.165$, $P = 0.649$; LE Pasta: $r = 0.567$, $P = 0.087$; HE
260 Porridge: $r = 0.565$, $P = 0.089$; HE Pasta: $r = 0.909$, $P < 0.0005$). Energy compensation at the ad
261 libitum meal was significantly correlated with the change in AUC and 60 min composite appetite
262 scores between the 828 kJ and 4188 kJ preloads for the pasta meal (AUC: $r = -0.758$, $P = 0.011$; 60
263 min: $r = -0.673$, $P = 0.033$) demonstrating greater energy compensation in response to larger
264 reductions in appetite. However, these correlations did not reach statistical significance for the
265 porridge meal (AUC: $r = -0.498$, $P = 0.143$; 60 min: $r = -0.499$, $P = 0.142$) (Figure 5).

266 DISCUSSION

267 The use of ad libitum meals to quantify energy intake is a prominent methodology within appetite
268 and energy balance research. This investigation represents the first comparison of the sensitivity of
269 two commonly used single course ad libitum meals in response to appetite manipulation. The findings
270 demonstrate that the provision of a moderately palatable porridge-based meal reduces
271 overconsumption in comparison with a more highly palatable pasta-based meal. However, energy
272 compensation at the pasta meal was more strongly correlated with preceding appetite ratings,
273 demonstrating greater sensitivity to appetite manipulation.

274 The incorporation of two experiments within this report enabled the sensitivity of the test meals to be
275 investigated in response to a moderate and large manipulation of preload energy content. Surprisingly,
276 the 1197 kJ difference in energy content between preloads in experiment one did not produce any
277 discernible changes in appetite or energy intake. This finding contrasts with previous research that
278 has reported reductions in appetite and an energy intake compensation of 30 – 57% in response to
279 preload energy manipulations of ~1500 kJ^(19,30). The participants recruited for the present experiment
280 were all young, healthy, recreationally active men and an intermeal interval of 60 minutes was used
281 based on evidence that this population and experimental design will maximise the compensatory
282 response to preload manipulation^(19,26,31,32). Subsequently, it is not clear why the preload manipulation
283 failed to alter appetite responses but this may be related to the composition of the preload beverages.
284 In this regard, although similar preload beverages have been found to influence appetite and energy
285 intake through the manipulation of maltodextrin content^(19,33), the increases in preload energy during
286 the present study were primarily achieved via the addition of maltodextrin *and* single cream. Such
287 sugar-fat combinations are frequently used in laboratory models to promote hyperphagia⁽³⁴⁾ and any
288 appetite-stimulating properties of the higher energy preload may have compensated for the appetite-
289 suppressing effects of the moderately increased energy content. This finding supports longstanding
290 concerns regarding the weak satiating effects of high sugar and fat dairy-based beverages and their
291 likely contribution to a positive energy balance⁽³⁵⁾.

292 The increased manipulation of preload energy content in experiment two successfully generated
293 divergent appetite and energy intake responses between the high and low energy preloads.
294 Compensatory reductions in energy intake during both ad libitum meals after consumption of the high
295 energy preload in experiment two and the absence of change in energy intake during both meals in
296 experiment one supports the use of these meals to reflect preceding appetite ratings. However, the
297 findings of the present study reveal important strengths and limitations for the use of these meals in
298 future appetite research.

299 In accordance with previous research, the pasta-based ad libitum meal induced significant
300 overconsumption in both experiments^(1,14–20), which conflicts with current recommendations for ad
301 libitum meals to reflect habitual energy intakes⁽⁷⁾. In this regard, energy intakes during the pasta meals
302 were more than 50% higher than the respective porridge meals and occurred despite the meals being
303 matched for energy density. This difference appears to be due to the highly palatable nature of the
304 pasta-based meal and is supported by previous research demonstrating that highly palatable foods can
305 stimulate appetite during ad libitum feeding, thereby overriding signals of satiation and increasing
306 energy intakes^(22,36). The moderately palatable porridge meal produced energy intakes that were more
307 representative of expected habitual intakes, which demonstrates the importance of considering and
308 reporting the palatability ratings of ad libitum meals within research studies. Additionally, such large
309 differences in intakes occurred despite participants having higher habitual intakes of pasta-based
310 meals, which would be expected to improve the environmental contingencies associated with this
311 food and reduce intakes to more ecological levels. This further emphasises the importance of
312 palatability as a determinant of energy intake during ad libitum feeding.

313 Although large inter-individual variation in short-term energy compensation has been previously
314 documented^(19,30,37), the findings of the present study suggest that this may be accentuated by the
315 provision of a highly palatable ad libitum meal in response to appetite manipulation. In this regard,
316 higher energy intakes during the pasta meal were associated with markedly greater heterogeneity in
317 the compensatory response to preload manipulation in experiment two. It seems likely that the higher
318 energy intakes of the pasta meal provide opportunity for greater compensatory responses (i.e. larger
319 changes in energy intake) to the observed decrease in appetite perceptions. Alternatively, the modest
320 energy intakes observed during the porridge meal after consumption of the low energy preload appear
321 to have limited the potential range available for reductions in energy intake in response to the large
322 manipulation of preload energy content in experiment two and produced a more homogenous
323 response. In this regard, although participant blinding was unsuccessful, the participants were
324 unaware of the energy content of the preloads, which maintains the impact of environmental
325 contingencies on food intake and encourages consumption during both meals⁽³⁸⁾. Such unsuccessful
326 blinding is an expected consequence of the experimental manipulation as the preload beverages were
327 designed to produce contrasting appetite responses. Although subtle differences in preload
328 appearance may have contributed to the observed appetite responses⁽³⁹⁾, the successful blinding of
329 experimenters presenting the beverages suggests that post-ingestive consequences from preload
330 consumption may have dominated.

331 Despite overconsumption and high levels of heterogeneity in compensatory energy intake responses,
332 energy compensation during the pasta-based meal was strongly correlated with appetite changes in

333 response to the high versus low energy preload (i.e. larger reductions in appetite were associated with
334 greater energy compensation). Furthermore, this was superior to the correlations observed between
335 changes in appetite and the more ecologically valid energy intakes achieved during the porridge meal.
336 These findings suggest that the increased range available for compensatory feeding responses as a
337 result of the overconsumption of a highly palatable meal may enhance the sensitivity to reflect
338 preceding appetite ratings and improve alignment between these variables. Subsequently, despite
339 current recommendations for ad libitum meals to reflect habitual energy intakes⁽⁷⁾, the present study
340 provides evidence that this may limit the sensitivity of the meal to reflect preceding changes in
341 appetite. However, it must be acknowledged that mean energy compensation was not different
342 between the test meals, which suggests that both meals are sufficiently sensitive to detect
343 compensatory responses to appetite manipulation.

344 In conclusion, the experiments contained within this investigation have demonstrated compensatory
345 changes in energy intake in response to appetite manipulation when assessed using either a pasta-
346 based or porridge-based ad libitum meal. The provision of a highly palatable pasta-based meal
347 induced significant overconsumption but changes in energy intake were strongly correlated with
348 preceding appetite ratings. Alternatively, the ecologically valid energy intakes achieved with the
349 provision of a moderately palatable porridge-based meal were less representative of changes in
350 appetite perceptions. These findings support continuation in the use of a commonly employed pasta-
351 based ad libitum meal when the priority is to reflect preceding appetite ratings and suggest that the
352 large energy intakes observed during such feeding are unlikely to reduce the sensitivity of the measure
353 to reflect preceding changes in appetite. Alternatively, it seems that meals producing moderate energy
354 intakes during ad libitum feeding may limit the range of potential compensatory responses but could
355 be suitable when energy intakes reflective of habitual diet are preferable. Subsequently, future ad
356 libitum meal design may require a compromise between sensitivity and ecological validity.

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362 All authors contributed to the study design, data collection, data analysis and writing of the
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364 The authors declare no conflict of interest.

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458 **Figure 1.** Energy intake (a) and energy compensation (b) for experiment one. #Significantly different
459 between test meals. Values are mean (95% CI), $n = 10$.

460 **Figure 2.** Composite appetite scores (a) in the 579 kJ Porridge (○), 579 kJ Pasta (●), 1776 kJ Porridge
461 (□) and 1776 kJ Pasta (■) trials for experiment one. Dashed lines represent the low energy preload
462 trials. Values are mean (95% CI). Linear correlation with 95% CI between the change in composite
463 appetite AUC after the 1776 kJ versus 579 kJ preload and energy compensation for the pasta meal
464 (b) and porridge meal (c). $n = 10$.

465 **Figure 3.** Composite palatability scores for the preloads (a) and test meals (b) for experiment one.
466 #Significantly different between test meals. Values are mean (95% CI), $n = 10$.

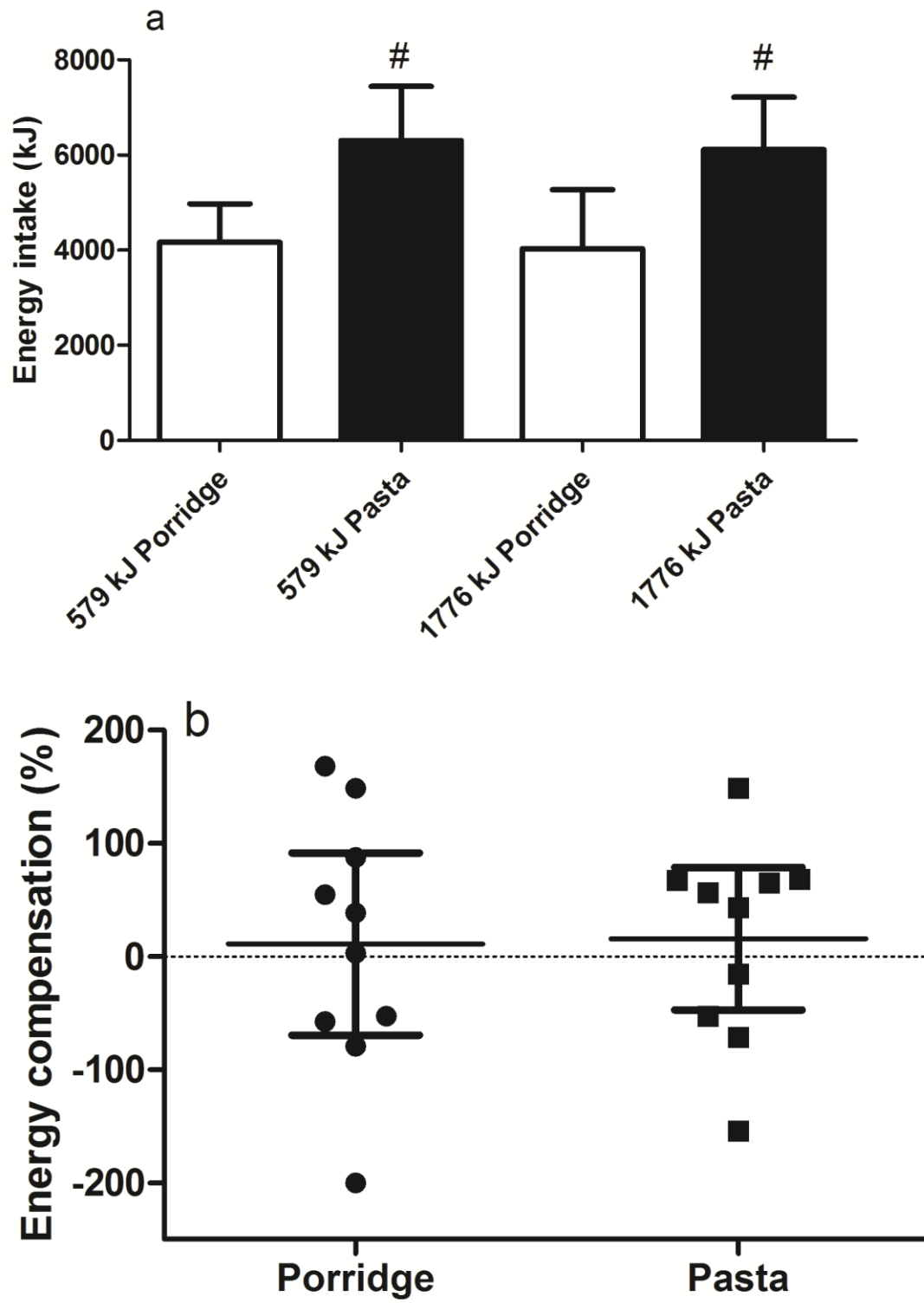
467 **Figure 4.** Energy intake (a) and energy compensation (b) for experiment two. *Significantly different
468 between preloads, #Significantly different between test meals. Values are mean (95% CI), $n = 10$.

469 **Figure 5.** Composite appetite scores (a) in the 828 kJ Porridge (○), 828 kJ Pasta (●), 4188 kJ Porridge
470 (□) and 4188 kJ Pasta (■) trials for experiment two. Dashed lines represent the low energy preload
471 trials. Values are mean (95% CI). Linear correlation with 95% CI between the change in composite
472 appetite AUC after the 4188 kJ versus 828 kJ preload and energy compensation for the pasta meal
473 (b) and porridge meal (c). $n = 10$.

474 **Figure 6.** Composite palatability scores for the preloads (a) and test meals (b) for experiment two.
475 *Significantly different between preloads, #Significantly different between test meals. Values are
476 mean (95% CI), $n = 10$.

477

Figure 1



478

479

Figure 2

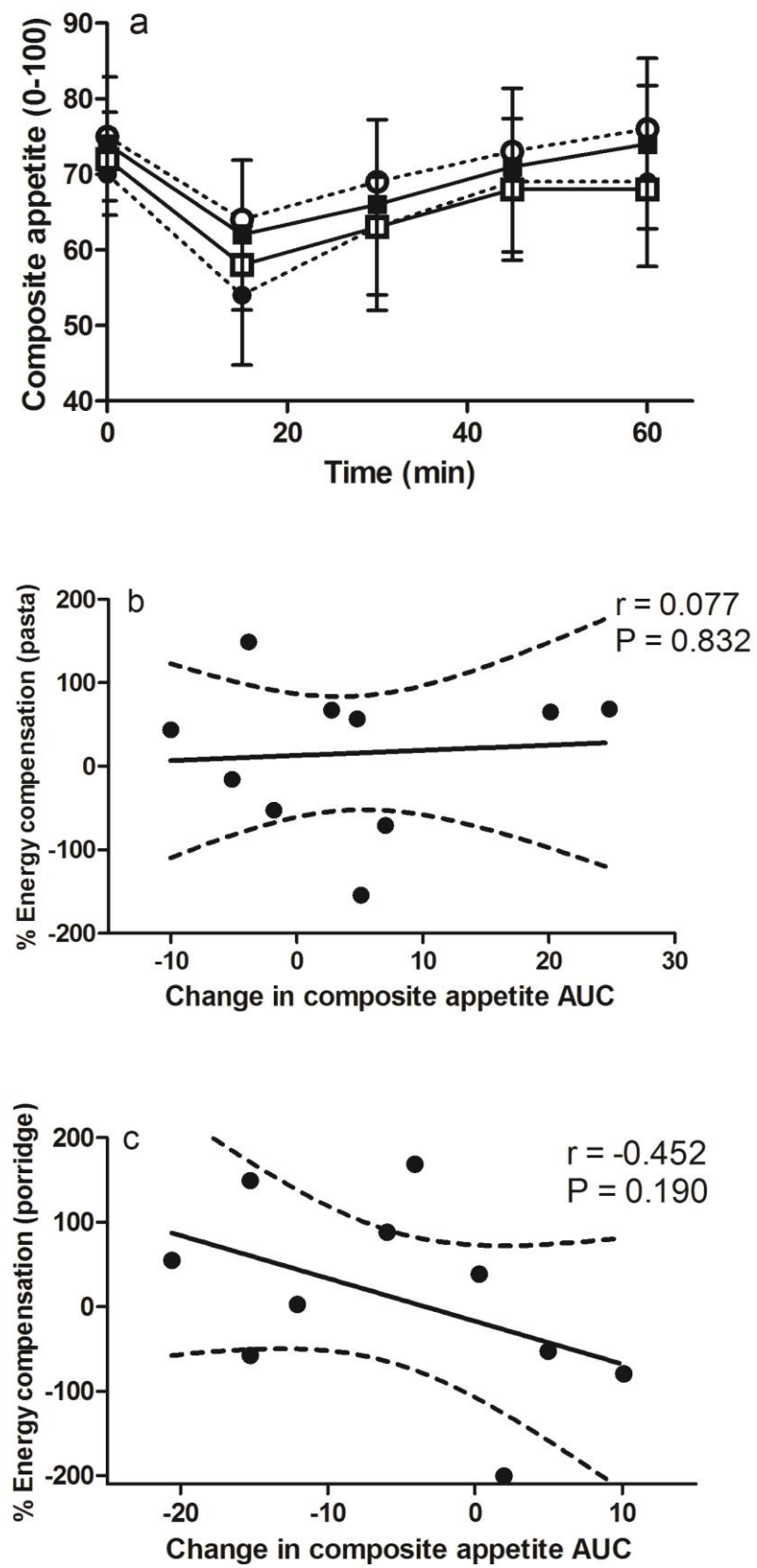


Figure 3

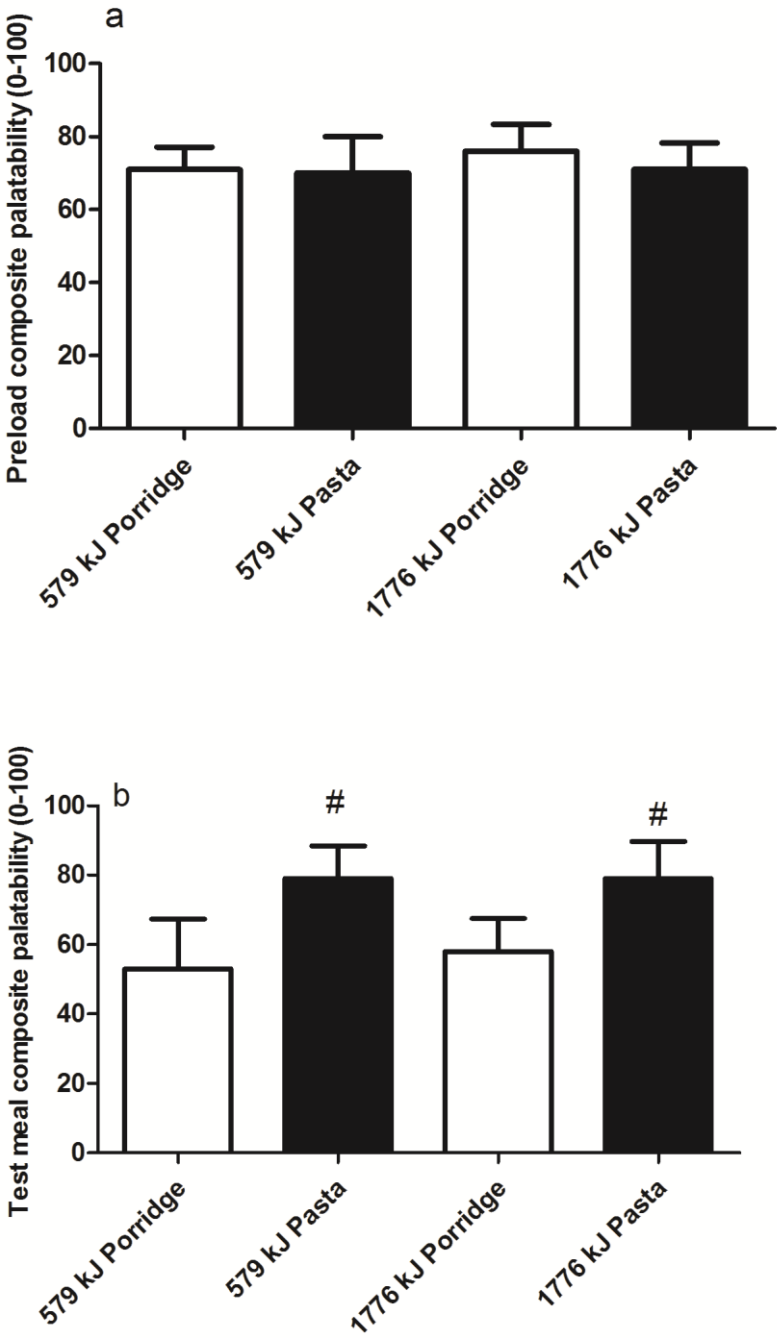


Figure 4

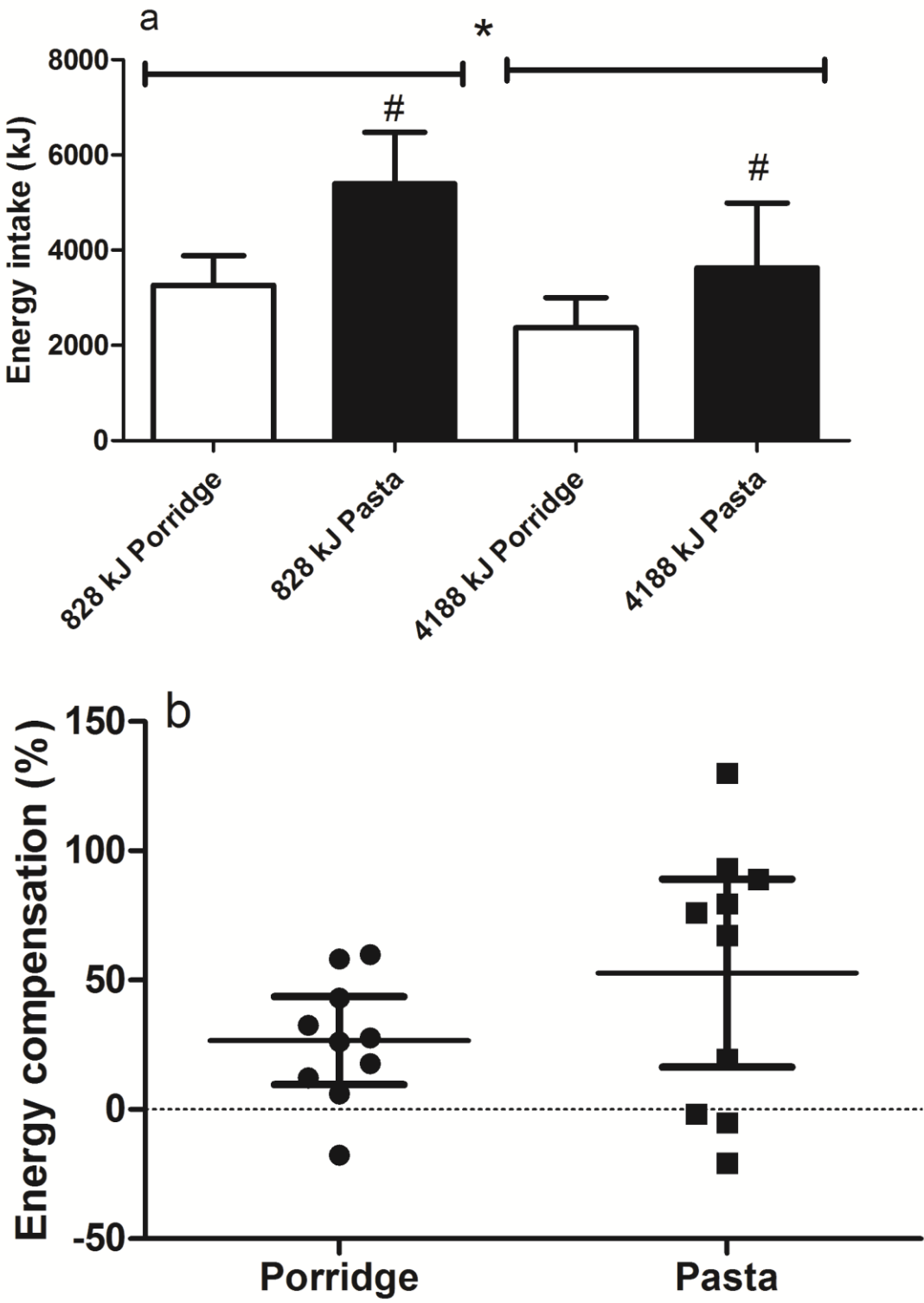


Figure 5

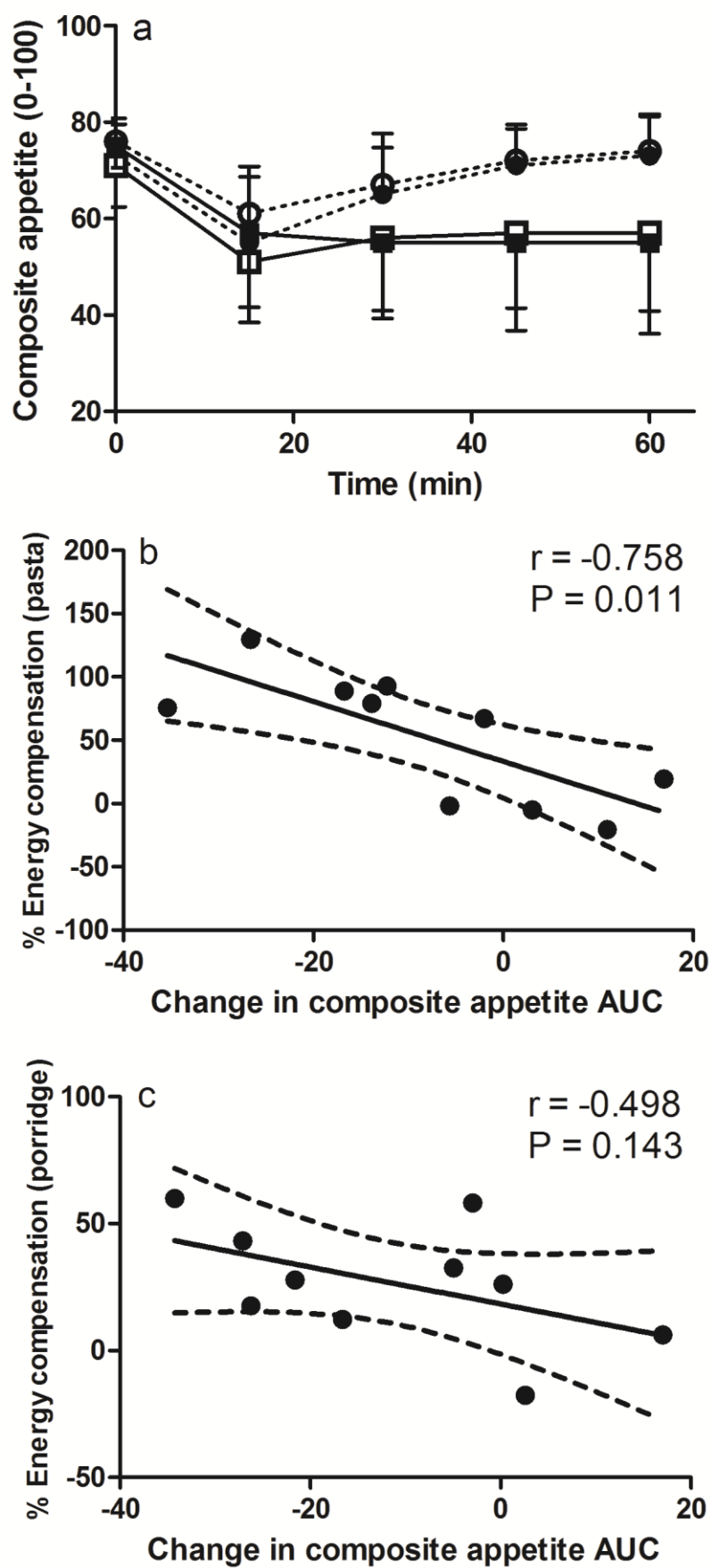


Figure 6

